

PB-216 760

STUDY ON SEPTIC TANKS AND SEPTIC TANK DISPOSAL SYSTEMS

T. W. Bendixen, et al

Environmental Health Center
Cincinnati, Ohio

1951

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

STUDY ON SEPTIC TANKS AND SEPTIC TANK DISPOSAL SYSTEMS

T. W. Bendixen, Soil Scientist
S. R. Weibel, Sanitary Engineer

U. S. Public Health Service
Environmental Health Center
Cincinnati, Ohio

(For Presentation at the Annual Meeting of the American Society
of Agricultural Engineers at Houston, Texas, June 19, 1951)

Studies on Household Sewage Disposal Systems are being conducted at Cincinnati by the Public Health Service as a cooperative project under the programs of the Administrator, Housing and Home Finance Agency, and the Public Health Service. That such studies are needed is evident from the lack of basic facts on the behavior of the various parts of these small systems.

The Joint Committee on Rural Sanitation, which consists of representatives of official municipal, state and federal agencies, has developed a set of uniform recommendations on individual sewage disposal systems, which are set forth in Reprint No. 2461 from the Public Health Reports, entitled, "Individual Sewage Disposal Systems, Recommendations of Joint Committee on Rural Sanitation." It is proposed that as definite conclusions are reached in the research studies under way at Cincinnati, this publication will be revised to include results applicable to systems serving suburban and rural homes.

As a guide to the size of this field, it has been estimated⁽¹⁾ that some 17 million persons in this country are dependent on septic tank-soil absorption systems, as compared with about 22 million persons being served by all other types of complete sewage treatment in municipal practice. Present trends towards living in suburban areas and the modernization of farm homes are making the place of these systems increasingly prominent.

A poll of local health departments over the country concerning local practice in this field has pointed out many problems for study. Aside from the technical aspects of design and installation of systems, the maintenance and care

LIBRARY
U. S. PUBLIC HEALTH SERVICE
ENVIRONMENTAL HEALTH CENTER

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. Department of Commerce
Springfield VA 22151

of the systems present additional problems. Individual household sewage disposal is a peculiar field of sewage treatment in that the servicing of the system is up to the householder. Unfortunately, he is not technically equipped for this function and, in many cases, he is totally unaware of any responsibility on his part to maintain and service the system in order to avoid trouble. We are told by septic tank cleaners, for instance, that in over half the cases in which cleaners are called in, the owner has not acted in time, the tank has gone beyond its capacity to store solids, and solids have been carried over and filled the soil absorption field. Now, while it is possible to renew the usefulness of the tank by cleaning, the soil absorption field is another story.

We bring this up because we feel that solving the many strictly technical problems of treatment and disposal is not the complete solution. Along with it must come the means whereby the facilities will receive the attention necessary for proper operation. We know from experience, in the areas in which we have conducted examinations of residential systems, that in many cases the householders seemed to be much interested in their sewerage facilities, but did not know what facilities they had, where they were, nor that attention was required. A little advice to the householders, and education on servicing responsibilities, will cut down considerably on the number of headaches in this field.

As to the technical side of the story, our studies are separated into two parts--the septic tank proper and the soil absorption fields. For simplicity in discussion we shall take them up in that order.

Tank Studies

A total of 300 single-household-type septic tank systems were examined in nine areas of the country. Such examinations were of primary interest for the establishment of rates of scum and sludge accumulations in operating systems. It

appears that scum and sludge tend to accumulate volumetrically in the septic tank at a higher rate per person per year during the earlier years of service than after some six years of operation; after that it appears to increase at a more or less constant rate. Average trends of the rate of scum accumulations were 0.43 cubic feet per person per year at the three-year point and 0.41 at the six-year point; sludge accumulation rates were 1.28 cubic feet per person per year at the three-year point and 0.95 at the six-year point. These are average figures, and for design purposes attention must be given to variation from average. In order to cover say, 19 out of 20 cases, considering the individual variation, one would need almost to triple the average scum accumulation rate and double the average sludge accumulation rate at the three-year point, and increase by almost double and almost $1\frac{1}{2}$ times the respective average rates at the six-year point.

The smaller tanks tended to accumulate smaller volumes of scum and sludge, and the larger tanks larger volumes, than the average. This trend might serve as a rough yardstick of the effect of tank capacity on solids removal efficiency. It would indicate that the larger tanks are more efficient in settling.

Concerning structural tank materials, it appears that corrosion is most severe, inside the tank, at and above the water line. In general, pre-cast concrete, tile, and brick stood up well for twenty years or more; poured-in-place concrete, for at least 10 years (no data for older tanks); steel tanks, a seven-year useful life on the average, running as high as 12 years in individual cases in the groups of tanks examined. Wood baffles were found sound in tanks up to seven years old (no data for older installations).

Coming to the laboratory studies, one of the first questions to be answered is the effect of tank shape and tank capacity on settling efficiency. Five single-compartment tanks, all of approximately 500 gallons capacity but of different shapes (vertical and horizontal cylinders, rectangular, oval, and rounded end) were operated

for a year at the laboratory, all under the same conditions of loading, accelerated sludge accumulation, and other details of operation. The suspended solids removal efficiencies of all five tanks for the year were between 59 and 65 per cent. In other words, for the same capacity, variation in shape appeared to effect efficiency very little.

The variation in liquid depths among these tanks was too small to be indicative of behavior under any radical departure from four feet, which is the depth recommended by the Joint Committee on Rural Sanitation.⁽²⁾ It did appear, however, that a small variation, say, half a foot, would make little difference in efficiency as compared with the four-foot depth. Study of the depth factor is now under way.

A 2000-gallon single-compartment tank operated under the same sewage loadings, but with larger sludge additions, gave an 82 per cent removal, and two multi-chambered tanks of 550 and 670 gallons capacity respectively, under the same loadings and sludge accumulation conditions as the five 500-gallon capacity single-chamber tanks, gave removals of 78 and 84 per cent respectively. In other words, either a larger capacity or some sort of compartmentation appears to improve efficiencies. Smaller tanks, both single- and multi-chamber, operated at respectable efficiencies for a very short time, reaching sludge storage capacity quickly, which of course would mean frequent cleaning intervals. Our conclusions are, consequently: that variation in shape of single-compartment tanks, within reasonable limits, does not effect efficiency if capacity is adequate; that some sort of compartmentation appears desirable; and that, while no unqualified conclusion on capacity can be drawn from the study thus far, we believe that tanks of at least 500 gallons capacity should be provided, to insure reasonably long periods of trouble-free service, and to prevent frequent and progressive damage to the absorption system due to sludge discharge.

Several exploratory trials of tank inlet, outlet, and inter-compartment flow appurtenances have been made. For the sake of obtaining some quick exploratory results, these were run on the basis of detention time, using urania dye as a tracer. Ultimately, suspended solids performance trials must be carried through on promising arrangements. Concerning a tee inlet, baffled sewer inlet, and plain sewer inlet, experimental comparison on the basis above mentioned indicated that there was essentially no difference in the experimental detention time among the three inlets. There was, however, an indication of a slightly better flow pattern for the tee inlet, followed by the baffled inlet and the plain sewer inlet in that order. Operating two three-compartment rectangular tanks, one equipped with inverted U's between compartments, and the other, first with a 4-inch horizontal tank-width slot, and later with a 4-inch diameter hole, with both submerged 12 inches from the liquid surface to the top of the opening, it was found that the slot at this position gave the same experimental detention time as a tee-fitted single-compartment tank of equal capacity and only half the detention time of the inverted U-equipped compartmented tank. Upon constricting the slot opening to that of a 4-inch diameter hole at the same depth, the detention period lengthened, but did not come up to that of the inverted U-equipped tank. These are, of course, at one position, and other locations are to be investigated. One experiment on outlets has been performed in which there was no essential difference in suspended solids removal from two identical tanks, one operated with a tee outlet and the other with a baffled tank-width weir. Other outlet experiments are under way, in connection with the depth studies, in which the behavior of tanks with respect to depth, and also with respect to the distance between top of the accumulating sludge and the bottom of the outlet, is being observed. These are not far enough along to report at this time.

The matter of intervals between cleaning, or the point at which a tank should be cleaned, is pertinent. There is some indication in the field data that there may be a relation between the bottom of outlet and a limiting sludge storage level. If this should bear out in the experimental work now under way, it would mean that the tank could accumulate sludge to a certain distance below the outlet, possibly regardless of the over-all liquid depth of tank or sludge. The proper design for a particular total liquid depth would, in such case, be arrived at by deducting the outlet-to-sludge distance from the total liquid depth, dividing the remaining vertical distance in proportion to the sludge and scum accumulation expectancy, and locating the bottom of the outlet slightly below the calculated bottom of scum. Here again, for design purposes, the wide variation in individual cases limits the value of an average, and provision for such a variation should be made. The detailed study of this will be presented at a later date.

Exploratory studies have also been made on the behavior of systems under various circumstances, namely: (1) the addition of ground garbage, (2) the addition of household detergents rather than soaps to the system, and (3) the addition of proprietary compounds purported to "condition" or to "clean" tanks.

As for ground garbage, comparison of the effluent characteristics of two identical experimental septic tanks operated for a year, one receiving ground garbage in addition to sewage, the other sewage only, indicated that for about nine months the effluent suspended solids of both tanks were about the same, but during the last three months of the year's run the garbage tank effluent suspended solids ran considerably more than that of the sewage tank. It is obvious, of course, that if additional solids are discharged to the tank the rate of accumulation of sludge will increase, and that either the tank capacity must be increased accordingly or cleanings must be made at more frequent intervals. Until further information is available the 50 per cent increase in tank capacity recommended by the Joint Committee⁽²⁾ where garbage loadings are anticipated, appears to be a reasonable amount.

The behavior of tanks receiving wastes from households using detergents for laundering and dishwashing is a subject of current interest. There have been system failures, or failures earlier than usual, attributed to automatic-sequence washers. There are several elements involved here: The quantity of waste is one, and the effects of detergent wastes on tank action and on the soil behavior are others. We know from exploratory experiments by Rudolfs⁽³⁾ on a few household-type detergents that increasing detergent concentrations, up to 100 ppm tested, tends to decrease suspended solids and grease removal during short-period settling. Some of the detergents are broken down fairly easily by biological action and others are not, and this may be of importance to the sewage disposal system. Specific effects of detergents on soil behavior will be discussed later.

The application of proprietary compounds purported to "condition" tanks, and even to "clean" tanks, is a point on which we receive inquiries rather frequently. While we cannot undertake to test the many compounds as such, we hope to complete tests on a few of the common active agents. We found through experiment that yeast did not have merit as a tank "starter" and that ripe sludge was of advantage. Preliminary indications in a recent experiment on the application of caustic soda, which is the active agent of some of the so-called "cleansers" on the market, are that, while the suspended solids removals do not appear to change, there is at least a temporary rise in the ratio of volatile matter. After addition of the caustic, the pH of the effluent rose to about 12.4, remained above 11.0 for five days, and did not return to the normal value of about 7.0 until after about 10 weeks. In our estimation, a reasonably well-designed tank needs no such props and, if inadvertent discharge of interfering materials has upset tank action, the simplest and safest remedy for the protection of the all-important soil absorption system is to pump out the tank and start over.

Soils Studies

The second part of the disposal system, the soil absorption field, is in some ways more important than the tank itself. The success or failure of the entire system is generally judged by the efficiency of the disposal field,, and regardless of how good a tank may be, if the absorption field does not operate properly the system can be a failure. However, we do not intend to minimize the necessity for a good tank; we should strive for the best over-all system possible, which includes both a good tank and a good absorption field.

Before we get into a discussion of the soils studies, we would like to point out the tremendous amounts of wastes that we expect the soil of a typical absorption field to absorb, as compared to the amounts of water it must absorb normally from rainfall or even from irrigation. The average rainfall of the country varies from 30 to 50 inches per year, with extremes ranging from 6 to 150 inches per year. After allowing for stream runoff, evaporation, etc. of part of the rainfall, the soil is required to absorb the remaining amount, which is in the neighborhood of 20 to 40 inches with a maximum of possibly 100 inches per year. Under irrigation the maximum amount of water applied annually is also in the neighborhood of 100 inches. As compared to these figures, the amount of effluent applied to a disposal field based on current design practice ranges from 200 inches annually in the tighter soils to over 600 inches annually in the more porous soils. In extreme cases encountered in the field, amounts of over 2,000 inches were being applied. This comparison indicates that our problem is a major one from this viewpoint alone, without the complicating influence of soil clogging factors which we know exist under sewage or effluent dosing conditions.

The general problem, as far as the disposal system is concerned, is to determine the amount of soil absorption area to provide for any specific system.

The answer to this problem depends in turn on a number of factors, such as the clogging characteristics of the effluents, the volume of effluents to be disposed of, the climate of the area and, most important, the water absorption characteristics of the specific soil being considered.

In the sewage disposal field the work done by Henry Ryon⁽⁴⁾ in the 1920's, and reported by Federick⁽⁵⁾ in 1949, has provided a useful tool for estimating soil moisture absorption rates and needed absorption areas. Ryon proposed the percolation test, which has since become very widely used, by which he measured the rate that a soil would absorb clear water. He also developed an empirical relationship between this clear water rate and the rate that the soil could be expected to absorb sewage or septic tank effluent successfully. It is this test and empirical relationship, or slight modifications thereof, upon which most of the soil absorption field specifications of the various control agencies are now apparently patterned.

However, despite the usefulness and the widespread utilization of the Ryon test, there is considerable room for its improvement. In detail, the Ryon test is made by excavating a hole one foot square to the anticipated depth of a proposed absorption field, and saturating the hole by filling with water and allowing it to seep away. The hole is then filled with water to a depth of about six inches, and the time required for the water level to fall one inch is measured.

We have proposed a number of modifications of the test, which in our opinion are improvements. These modified tests have been studied and compared to a Ryon-type test on a variety of soils. In brief, these modifications are: (1) the substitution of a small bored hole for the dug hole; (2) the more complete saturation of the soil; and (3) the use of the minimum observed rate instead of the average, or some initial, rate.

The first modification is to substitute a four-inch auger hole for the one-foot-square dug hole. This is a minor change to be sure, but a potentially important change from the viewpoint of the person who has to make the tests. The auger hole can be prepared with much less time and labor, and requires a smaller volume of water. The saving of water alone can be quite a consideration if the water must be carried to the site. The time and labor saved can be profitably used for making additional tests in the area being considered. Due to the inherent variability of soils, a single test is often useless in estimating the absorption characteristics, say, of a 100-foot-square area. In such an area, probably four to six tests or more are necessary.

Comparative percolation tests employing a four-inch auger hole, an eight-inch auger hole, and a one-foot-square dug hole in a variety of soils have shown that there is no significant difference in the rates measured in the different sized holes. In Table 1, data obtained on three soils representing a wide range of rates and absorption conditions, are given as indicative of typical results. It is quite apparent that the variation between replicates of a single sized hole is as great or greater than the variation in rates between different sized holes.

Another suggested modification of the percolation test is to provide for a more specific procedure for insuring saturation of the soil. Anyone who has made a percolation test is familiar with the decrease in rate that may take place over the early part of the test. The magnitude of this decrease depends upon prior moisture conditions and upon soil type. The decrease will be more pronounced if the test is started in a dry soil, and is likely to be more pronounced in a clay-type soil than in a sandy-type soil. We have made a rather detailed study of this percolation rate decrease in several different soil types in order to judge its practical importance.

TABLE 1 - Replicate Percolation Rates Measured in Three
Different Sized Holes in Three Soil Types

Replicate No.	Rossmore			Genesee			Brookston		
	12" Sq.	8" Rd.	4" Rd.	12" Sq.	8" Rd.	4" Sq.	12" Sq.	8" Rd.	4" Rd.
	----Inches per Hour----								
1	1.6	1.6	1.6	10.4	8.4	8.4	19.5	15.5	17.5
2	1.0	1.7	1.0	7.8	8.2	9.6	16.7	23.9	15.9
3	1.3	1.3	1.3	6.4	6.4	9.0	20.5	17.7	13.8
Average	1.3	1.5	1.3	8.2	7.7	9.0	18.9	19.0	15.7
	----Minutes per Inch----								
1	37.5	37.5	37.5	5.8	7.1	7.1	3.1	3.9	3.4
2	60.0	35.3	60.0	7.7	7.3	6.2	3.6	2.5	3.8
3	46.1	46.1	46.1	9.4	9.4	6.7	2.9	3.4	4.3
Average	47.8	39.6	47.9	7.6	7.9	6.7	3.2	3.3	3.8

Percolation test holes were installed in triplicate at several soil sites which were selected for their uniformity of soil. The prior moisture conditions were about normal, neither excessively dry nor excessively wet. After digging the holes, the sides and bottom were scarified with a sharp pointed rod to remove any smeared surfaces, which, incidentally, is a good general practice, and two inches of washed pea gravel were placed in each hole to prevent soil scouring. City tap water was used in all of the tests. The temperature of the water during any complete test was maintained at about 75° F.

The test holes were filled with water to a 12-inch depth, and water level measurements made at 10- to 15-minute intervals were continued over a four-hour period, refilling the holes as necessary. This test will be referred to as the dry run. At the end of the day, the holes were filled with water and allowed to soak overnight. On the following day, testing was continued over a four-hour period, presumably under more completely saturated conditions. This will be referred to as the wet run.

Percolation rates have been calculated from the data in two ways: (1) the average rate for each run, and (2) the equilibrium rate for each run, which is taken as the rate over the last 30-minute period of each day, and which was always measured under minimum head conditions. The average rate of the dry run can be considered comparable to a typical Ryon type test.

The practical significance of obtaining rates under saturated conditions may be noted in Table 2, in which the results from three typical soils are summarized. The absorption areas required have been calculated on the basis of the Joint Committee on Rural Sanitation tables. The Rossmoyne soil site, if considered on the basis of the average dry run rate of 44 min./inch which, as we have said is comparable to a typical Ryon-type test rate, would be considered

acceptable for an absorption field. Approximately 208 square feet of absorption area per bedroom would be required. However, if the site is considered on the equilibrium dry run rate of 66 min./inch, the site would be on the borderline of being acceptable. The Joint Committee tables set the minimum acceptable rate at 60 min./inch. If the site is considered on the basis of either of the wet run rates, it would be completely unacceptable.

The latter case agrees with the performance of this soil under actual operating conditions. Of several systems inspected that were operating in the Rossmoyne soil type, which is a dense structureless clay soil with low swelling properties, not one was considered to be satisfactory by the home owners. One system, about five years old, inspected in detail, having approximately 300 square feet of absorption area, and receiving toilet wastes only from one adult and two children, was found to be completely flooded and had serious surface seepage. The inspection was made during August, when temperatures were high, vegetation over the area was lush, and conditions in general should have been most favorable for successful operation.

With the Genessee soil, which is a silty-type soil, all of the rates are more nearly the same, varying from 7.2 to 10.9 minutes/inch. However, the rate measured under the most saturated condition would require about a 10 to 20 per cent larger absorption area than would the rate under the least saturated conditions.

The Brookston soil site is probably an extreme of what may be expected of a percolation test under varying conditions of saturation, but it is typical of a large group of soils. This soil is a well structured clay which undergoes a wide range of shrinking and swelling under varying moisture conditions. As the soil dries out, the structural units, or aggregates, shrink and numerous cracks

TABLE 2 - Effect of Percolation Test Modification on Measured

Pates and Estimated coil Absorption Areas Required

SOIL TYPE	DRY RUN						WET RUN					
	Average Rate			Equilibrium Rate			Average Rate			Equilibrium Rate		
	in/hr	min/in	Area* Sq.ft/B.R.	in/hr	min/in	Area* Sq.ft/B.R.	in/hr	min/in	Area* Sq.ft/B.R.	in/hr	min/in	Area* Sq.ft/B.R.
ROSEMONE	1.4	44.4	208	0.9	66.6	N.G.**	0.6	100.0	N.G.**	0.3	200.0	N.G.**
GEMESSE	8.3	7.2	69	6.5	9.0	100	6.0	10.0	103	5.5	10.9	109
BROOKSTON	17.9	3.4	62	13.9	4.3	71	8.2	7.3	90	5.5	10.9	109

*The absorption area required per bedroom for residence installations is based on Joint Committee specifications, Reprint No. 2461, U.S. Public Health Service.

##H.G. - Soil not acceptable.

and crevices develop which, when water is subsequently added, allow a very fast absorption rate. As the soil is kept wet, the units slowly saturate and swell, closing up the cracks and crevices and reducing the absorption rate. This effect is quite apparent in Table 2. The average rate of the dry run is over twice as fast as the average rate of the wet run, 3.4 to 7.3 min./inch. Likewise, the equilibrium dry run rate is over twice as fast as the equilibrium wet run rate. The required absorption area should be almost doubled, if it is based on the slower equilibrium wet run rate. The equilibrium rate is undoubtedly more representative of this soil under actual tile field conditions.

It might be argued that a saturation procedure could be carried to extremes, and that we would still get rate decreases even after several days of testing. Such an argument may be valid since percolation rates are known to continue to decrease under prolonged submergence and testing. Rates tend to approach a minimum in an asymptotic manner. However, such decreases are small, and are a function of factors other than saturation and swelling, and need not concern us for the moment. With the modified test, we are attempting to insure saturation and swelling in order to get beyond the point on the percolation rate curve where the large changes in rate take place. We feel that the modified test will do so in a great majority of cases, and more representative rates will be obtained consistently.

Improvement of the percolation test, and thus the securing of slower rates, immediately raise the question of the validity of using such rates for design of absorption fields on the basis of the present allowable loading rate tables. The slower rates obtained by the modified test will of course require larger absorption areas than rates obtained by the older standard tests. Such a design will be on the safe side at least, so that for the time being all we can say is that the modified test rates can be safely used with present tables.

However, it would be desirable to develop new and additional percolation rate-allowable sewage loading rate tables for a number of reasons. First, of course, the relationship may be different when a more rigidly controlled test is used for measuring percolation rates. Secondly, the relationship may, and probably does, vary with different soil types. The empirical relationship given by Ryon was developed under the limited soil conditions occurring in New York; and, furthermore, it was developed with a limited amount of data. An entirely different relationship may be applicable under midwest soil conditions, for example, where the soils tend to be deeper, or under southwest conditions where the soils are drier. Thirdly, the relationship may vary with different sewage characteristics. Obviously, the Ryon relationship was developed under sewage characteristics prevailing at that time. With the increasing use of home garbage grinders, the use of automatic washers, the use of detergents to replace soaps, etc., the sewage characteristics may be somewhat different today.

We have not yet been able to develop any new empirical relationships, which will entail a tremendous field study, but we are doing the next best thing - investigating some of the individual factors which may effect the relationship. One of the first and basic things we want to know is what are the specific characteristics of septic tank effluent which may effect the relationship by causing soil clogging. Logically, we may consider the causes of soil clogging in three categories: (1) physical clogging, (2) biological clogging, and (3) chemical clogging. Septic tank effluent is a complicated physical, biological, and chemical system, and may contribute towards all types of clogging.

The physical type of clogging is obvious. It may result from the physical plugging of the soil pores by the solid particles in the effluent. Biological

clogging, which is a common problem in agricultural water spreading work, (6) may result from the plugging of pores by biological bodies and by-products, or it may result from the biological activity destroying the soil structure. Actually, from preliminary studies, it appears that biological activity does not cause soil clogging under effluent dosing conditions, but rather tends to reduce clogging that might be caused by other factors. Laboratory soil cores packed with a variety of soils and dosed with effluent over a three-month period clogged in proportion to the amount of suspended solids in the effluents. After a few weeks of dosing, biological activity appeared to take effect to reduce the rate of clogging. Studies involving the application of normal and of disinfected effluent to soil cores showed a more rapid rate of clogging by the disinfected effluent, confirming the tendency of biological activity to reduce the rate of clogging. Apparently, a digestion of solid material takes place in the soil under normal effluent conditions, that results in a net decrease in the clogging effect of the effluent.

The third type of clogging, chemical clogging, is a common agricultural soils problem in the western part of our country, particularly under irrigation conditions. The classic example is the "black alkali" soils that develop in some areas as a result of irrigating with water high in sodium. For this reason, water quality has to be carefully controlled. It is generally considered that waters in which 50 per cent or more of the cations sodium, calcium, magnesium, and potassium, are sodium, are potentially harmful to the water absorption characteristics of the soil. (7)(8) Even on sandy soils waters of 85 per cent sodium or higher are likely to make soils impermeable after prolonged use. There are some indications that potassium may have similar effects.

The chemical quality of effluent will tend to vary with the water supply, so that the sodium problem may depend on the quality of water used. However, Wilcox⁽⁹⁾ has reported that there is a tendency for salt concentrations of sewage treatment plant effluents (primarily from Imhoff tanks) to be at least twofold greater than those of the water supply, and further, that the concentration of sodium in many of the effluents was disproportionately high. From this it appears that the possibility of effluents causing sodium clogging may be a problem for general consideration.

A laboratory study of sodium clogging has been attacked indirectly. Since it is the relative amount of sodium that is harmful, the percentage of sodium in effluents was controlled by increasing the concentration of calcium. This was done by adding a 0.1 per cent concentration of gypsum. With two of the four soil types included in the study, the addition of gypsum to the dosing effluent resulted in decreased clogging. In other words, the calcium-fortified effluent dosed cores maintained higher percolation rates over a period of several months of dosing, than did the normal effluent dosed cores. The soil types showing the effect had a well developed structure, and were apparently dependent on the structure for favorable percolation conditions. With the calcium-fortified effluent dosing, the structure was maintained; with normal effluent dosing, there was a noticeable destruction of structure with the accompanying increased clogging. The soil types showing no difference in clogging with the different effluent dosings were single-grained types, having no apparent structure.

Another possible source of chemical-type soil clogging, which has come to our attention through inquiries, is through the use of some of the chemical septic tank cleaning compounds. Advertisements indicate that some of these cleaners contain sodium hydroxide. Two brands of such cleaners, upon chemical analysis,

calculated as sodium hydroxide, contained the equivalent of about 95 per cent sodium hydroxide. Other cleaning compounds may contain potassium hydroxide.

Preliminary studies in which laboratory soil cores were dosed with effluents to which sodium hydroxide had been added, have given dramatic results. The effluents with the highest concentrations of sodium hydroxide, which were well below the maximum which can be expected from a typical cleaning dose, caused an immediate clogging of soil cores and an accompanying destruction of structure. After eight days of dosing only a trace of effluent was able to percolate through the cores, whereas the original percolation rates of these cores were approximately 150 cc/hour, which is equivalent to about seven min./inch. Concentrations of sodium hydroxide as low as .05 per cent caused serious clogging. Theoretical concentrations with recommended dosing may be as high as .6 per cent. Similar results were noted with potassium hydroxide. These results might have been predicted since sodium hydroxide is used as a dispersing agent in typical textural analysis procedures. The intent is to destroy the soils structure and to break it down into its smallest textural components. When a soil is so dispersed, it becomes a dense impermeable mass, exactly the opposite of the soil condition desired in an absorption field.

The aspects of tank behavior under ground garbage loadings were discussed previously. As far as the soils are concerned, there is definite evidence that septic tanks receiving ground garbage may require larger absorption fields. Dosing of sewage-garbage effluent to soil cores caused a more rapid rate of clogging than did the sewage-only effluent, both on a basis of equal length of time of dosing, and on a basis of an equal amount of suspended solids added. The soils ranged from a silty clay to a rather heavy clay. Based on the laboratory data, the additional area which would have been required for the cores receiving sewage-

garbage effluent to absorb equal volumes of effluent in the same time as the cores dosed with sewage-only effluent would be roughly 20 to 35 percent. I would like to emphasize, however, that this cannot be considered a final figure, as the results have been obtained on only four soil types and under laboratory dosing conditions. To develop a comprehensive figure will require investigation of the problem in the field. From these indications, if I were building a system for myself today, I would be inclined to increase its size by 50 percent to provide for the inclusion of ground garbage waste.

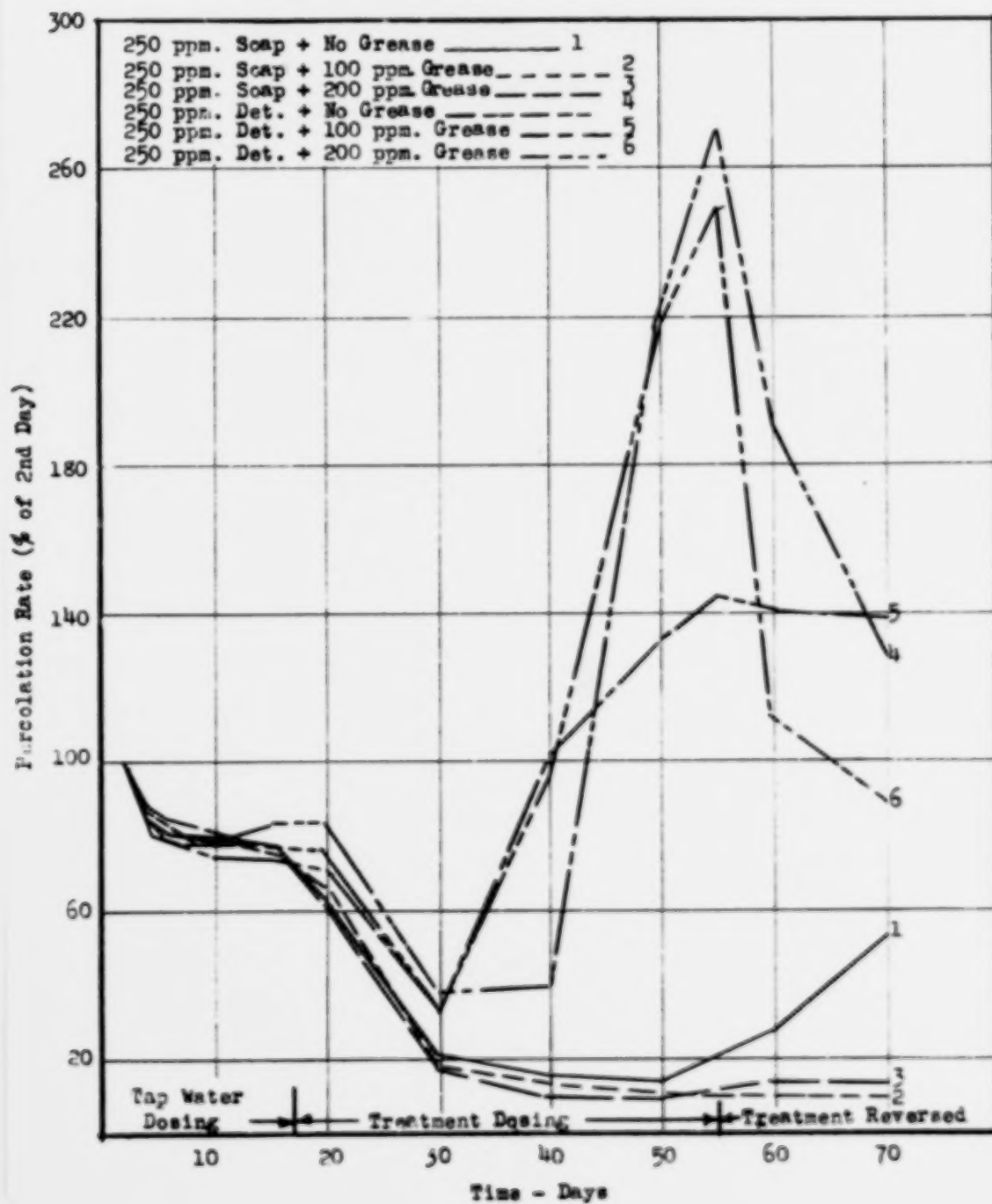
Another factor which may affect the percolation rate-allowable sewage loading relationship is the relative effect of detergents as compared to soaps. Some effects of a few detergents on efficiency of short time settling were previously pointed out. It might be suspected that the increased quantities of solids and of grease that would apparently be carried over to the absorption field would cause increased soil clogging. However, other factors may be involved, such as the effect of the effluent on soil physical properties and its effect on surface tension, so that the over-all effect of detergents on soil absorption systems cannot be simply deduced.

In recent exploratory studies at Cincinnati, effluents containing added concentrations of a household detergent and effluents containing added concentrations of household soap appear to have had no different effects on the clogging of laboratory soil cores. The clogging seemed to be more related to the amount of suspended solids in the effluent than to the soap or detergent treatments.

Similar core studies employing tap water solutions of the soap and detergent, in order to remove the complicating influence of the solids, but including the effects of grease, did show differential clogging. The results of these studies are shown in Figure 1. Each curve is the average of duplicate treated

Figure 1

Relative Effect of Soap and Detergent
Solutions with Varying Concentrations of
Grease on Soil Core Percolation Rates
Under Continuous Dosing



cores. The concentrations of soap, detergent, and grease used roughly approximate concentrations that might be expected in septic tank effluents.

The curves over the first 10-day period, during which time the cores were dosed only with tap water, are similar for all of the cores, and are typical. The reduction in rate over this period is probably caused by rearrangement of soil particles and by soil swelling. As soon as the soap and detergent solution dosings were started, there was further clogging. There was also an immediate tendency for the soap solutions to cause greater reduction in rates, or greater clogging, than the detergent solutions. After 30 days of dosing, the rates of the soap cores were reduced to about 19 percent of their original rates, while the detergent cores were reduced to about 35 percent. The original rates of the cores were about 1.2 in/hr.

Increasing quantities of grease in the soap solutions caused increased clogging; however, the differences were small. With the detergent solutions, the amounts of grease show no apparent correlation to soil clogging.

The most striking result of the study took place after about 30 days of dosing. At this time, the rates of the detergent cores began to increase and soon reached rates which were faster than the original. During this same period, the soap solution cores continued to clog. On the 55th day of dosing, the treatments were reversed and the clogging trends reversed. The cores then dosed with soap solutions immediately began to clog, and the cores then dosed with detergent solutions showed a tendency for the rates to increase.

The increase in rate of the detergent cores seemed to be associated with the surface tensions of the solutions. When the dosing treatments were added to the cores, their surface tensions were all depressed, compared to water, caused by the surface active material in the soap and in the detergent. After

the solutions had passed through the cores, their surface tensions were raised to about that of tap water, indicating that the surface active material was being removed during the percolation. However, when the rates of the detergent cores increased, it was noted that the surface tensions of the percolates were still depressed. The surface active material was evidently no longer being removed, and the reduced surface tension of the solution was effective throughout the core.

But before any one gets any cure-all ideas from these results, we want to emphasize that the results have been obtained under laboratory conditions and with only one soil type. And also remember that similar results were not obtained under effluent dosing.

As far as the separation of wastes for disposal in separate lines is concerned, which might be a natural thought, we see no advantage in this at this stage of our knowledge. Both field and laboratory studies will be undertaken on this point at the first opportunity.

The alternate or rotational use of tile lines is another question being investigated. A pilot-sized field study indicated that such intermittent use of tile fields may be beneficial, and may prolong the life of an absorption field. A series of four inch auger holes in a clay-type soil were dosed with effluent daily for about four months. Percolation tests were made daily, and that trend in rates was followed. At the end of four months, the holes would absorb effluent at a rate about 14 percent of the original. The holes were then allowed to "rest" for four months, and dosing again continued. The absorption rates during the second dosing period rose to about 23 percent of the original rate, and remained at this value for two months after which the study was discontinued.

One opportunity for full scale field study is being provided in Davidson County, Tennessee, by the local health department, where comparable tile lines in a large system are being used under continuous dosing and under alternate dosing conditions. Initial soil tests have been made, and subsequent tests will be made after a changeover in alternate lines.

All of the studies must be considered preliminary, with few definite conclusions reached to date. The results or trends are subject to change or qualification in the light of future developments.

References

- (1) Weibel, S. R., Straub, C. P., Thoman, J. R., Studies on Household Sewage Disposal Systems, Part I, 1949. Federal Security Agency, Public Health Service.
- (2) Individual Sewage Disposal Systems, Recommendations of the Joint Committee on Rural Sanitation. Reprint No. 2461 from the Public Health Reports (Revised 1947).
- (3) Rudolfs, W., Manganelli, R., Cellman, I. Effects of Certain Detergents on Sewage Treatment. Sewage Works Journal, V 20, No. 1, 1948.
- (4) Ryon, Henry, Notes on the Design of Sewage Disposal Works with Special Reference to Small Installations. Albany, New York, 1928.
- (5) Federick, J. C., Solving Disposal Problems in Unsewered Areas. Sewage Works Engineering, V 19, No. 6, 1948.
- (6) Allison, L. E., Effect of Microorganisms on Permeability of Soil Under Prolonged Submergence. Soil Science, V 63, No. 6, 1947.
- (7) Hutchins, Wells A., Sewage Irrigation as Practiced in the Western States. U.S.D.A. Tech. Bulletin 67, 1939.
- (8) McGeorge, W. T., Interpretation of Water Analysis. Univ. of Arizona Ext. Circular 107, 1940.